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Abstract

Process capital is the accumulated knowledge and established capability to exploit technology, process information, and organize resources in designing and managing work activities. Although it can extend and enhance the efficiency of manufacturing or the delivery of products and services for long-term value, few studies have discussed its specific content.

The objectives of this study are to investigate possible methods of measuring process capital and to test variables that can effectively reflect the value of process capital. This empirical study used a system model to identify three methods of measuring process capital: (1) process input—measuring the resources invested in process changes, (2) process management capability—measuring the management capability of the process changes, and (3) process output—measuring the results of the changed processes.

With a valid sample of 167 firms out of the top 522 firms in Taiwan, this study compared the firms' process input (investment in IT and process change), process management capability (process improvement), and process output (efficiency) with business performance over the period 2002–2005. The results reveal that (1) the input of process capital has low association with business performance in the short and long terms, (2)

process output has significantly positive association with operational and managerial performance in both the short and long terms, (3) process management capability has not only significantly positive association with operational and managerial performance but also partially and significantly positive association with strategic performance in both the short and long terms. Gaining an understanding of the value of process capital would need to involve a careful examination of the output and management capabilities of business processes and consideration of both the short- and-long term impacts.

Keywords: Process Capital, Process Value, System Model, Process Change Management.

Introduction

Process capital is the practical knowledge of processes, techniques and employee programs so that it can extend and enhance the efficiency of manufacturing or the delivery of products and services for long-term value (Edvinesson and Malone 1997). Process capital is the infrastructure portion of a firm's intellectual capital (Bontis 2000; Johnson 1999) and one of the major components of structural capital (Edinsson and Malone 1997; Bontis 2002; Van Buren, 1999). Although process capital plays an important role in organizing resources, processing information, interacting with stakeholders, and delivering organizational values (Kaplan 2004), few studies have discussed its specific content.

The objective of our measurement is to predict the value of the process capital and to aid organizational managers in planning, managing, and improving its value (Edvinsson and Malone 1997; Van Buren, 1999). Organizations have invested in information technology (IT) and programs to build process capital that ranges from IT infrastructure, quality improvement projects, process redesign projects, and enterprise systems, to various process integration projects. For example, world process investment in enterprise systems such as ERP, CRM, and SCM systems exceeds $5 billion (Shepherd *et al.* 2005; Morphy 2004; Fitzgerald 2006). However, failure to treat process capital as a separate and unique management issue is widespread among both companies and researchers. Process capital has usually been hidden in the measurement of organizational intellectual capital (Edvinsson and Malone 1997). The American Institute of Certified Public Accountants (AICPA), which requires companies in the United States to comply with its accounting rules for internal-use computer software, has issued SOP 98-1, offering the most practical definition of process capital.

This empirical study examines various ways of measuring process capital and tests the validity of the empirical measurements. We used a system model to identify three methods of measuring organizational processes: (1) process input—measuring the resources invested in process changes, (2) process management capability—measuring the management capability of the process changes, and (3) process output—measuring the results of the changed processes. This study examined the three kinds of process capital measurement against the degree of process improvement in large companies in Taiwan.

To measure performance, this study used three different measures of business performance, such as strategic (sales growth), managerial (Return on Assets; ROA), and operational (productivity), to trace and test measurement and management of this particular process over the short and long term. Using a valid sample of 167 firms out of the top 522 firms in Taiwan, this study compared firm process input (investment in IT and process change), process management capability (process improvement), and process output (efficiency) with business performance over the period 2002–2005. Gaining an understanding of the value of process capital would need to involve a careful examination of the output and management capabilities of business processes and consideration of both the short- and-long term impacts.

Conceptual Framework and Hypotheses

Process capital represents an infrastructural type of the intellectual capital that supports firm activities including sharing, exchange, flow, growth and transformation of knowledge from human capital to structural capital (Malhotra 2000). Kannan and Aulbur (2004) have also argued that process capital contains the skills, procedures, and programs that implement and enhance the delivery of products and services.

Measuring process capital is a critical part of a firm's strategic planning and execution. Since process capital consists of all work processes of structural capital, techniques (such as ISO 9000), and employee programs, it is a type of practical knowledge used in continuous value creation (Edvinsson and Malone 1997). Nevertheless, few companies define processes as capital unless they can be converted into a value-generation asset.

One way to organize measurements of process capital is to use the system model (input-process-output; IPO) perspective (Von Bertalanffy 1968) to align with organizational strategy in support of regular and innovative operations and satisfy customer requirements. However, many studies (Edvinsson and Malone 1997; Van Buren, 1999; Kautz and Thaysen 2001; Roos and Roos 1997) have tried to indicate the value of process capital according to either the input or the output of the capital at a certain time. Few studies have identified the management capabilities involved in managing process resources

(Teece 2000), Applying the concept of change management, this study constructs a third type of process measurement—the capability of managing process changes. All the following section describes the input-output-process (IOP) elements of process capital in sequence.

Performance

The history of business is essentially the story of finding methods for attaching a monetary value to activities and assets so that the Balance Sheet approach, a profit and loss approach, can enable firms to monitor the long-term flows between process and financial capital. Hence, indices of customer satisfaction, employee involvement, market position and knowledge must also manifest themselves as higher revenues, lower costs, or greater profits in the short or long term.

Organizational performance is influenced by numerous factors. The benefits from the process capital perspective should take several years to filter through business performance. For example, a new technology may take months to develop and years to transform into a real product, but it must turn into revenues for the enterprise at some point. Therefore, this study used measurement variables of the strategic (long-term), managerial (medium-term) and operational (short-term) performance to trace and test measurement and management of a particular process in the short and long terms.

The Input of Process Capital

Assuming rational behavior on the part of actors, the input of process capital has been used to predict the value of process capital (Weill 1990). Rational behavior, in an organization, means that firms maximize a given target function under the constraints they face in pursuit of their self-interest. Based on the literature and field studies (Chan 2005; Foss *et al.* 2002), an IT infrastructure for the system can help to explain the evolutionary path of investment from both the IT and organizational perspectives. Therefore, we can derive optimal economic behavior from the investment of process changes in a normative sense.

Previous research (Edvinsson and Malone 1997; Van Buren, 1999) has indicated that process capital has been included in intellectual capital as an indicator of either the cost of administration and IT or the efficiency and quality of the production or service. Hence, process inputs include not only IT investment but also administrative expenses. In other words, in addition to the investment in technology, investments in process capital include research and development (R & D), consultancy, and

operations, as well as organizational change and learning efforts. Consequently, these variables, including investment in IT and process change, can be used to explain and predict the future value of the processes.

H1: The greater the input of process capital, the better the business performance.

H1a: Investment of resources in process changes is positively related to operational performance.

H1b: Investment of resources in process changes is positively related to managerial performance.

H1c: Investment of resources in process changes is positively related to strategic performance.

The Output of Process Capital

Based on the concept of path dependency (Cohen and Levinthal 1990), measuring the results of process capital presupposes that the experience of previous process change leads to reduplicated or better results. By the same token, measurement of the output variables of process capital includes efficiency (cost, speed, and productivity), effectiveness (customer satisfaction, sales growth), flexibility (new products, new markets, new organizational structures), and strategic achievement of competitive advantages. It has become the most common method of measuring intellectual capital.

Previous research (Edvinsson and Malone 1997; Van Buren, 1999) has recommended using IT and operational performance to reflect the value of the process capital. Teece et al. (1997) indicated that where process capital goes is a function of its current position and the paths ahead. Firms with such capabilities can reduce adoption costs, since they tend to have a better understanding of the true costs, and perceive the difficulty of resource management while implementing further changes. Therefore, current performance of the processes, including efficiency, can predict the future value of the processes.

H2: The better the input of process capital, the better the business performance.

H2a: The result of the changed processes is positively related to operational performance.

H2b: The result of the changed processes is positively related to managerial performance.

H2c: The result of the changed processes is positively related to strategic performance.

The process capital management capability

The adaptive business must be designed to deal with the paradox between short- and long-term goals as well as strategies (Pasmore 1994). Teece (2000) has argued that few studies identify the capabilities of managing process resources adapted to changing environments as a key resource of process value creation. The changes associated with implementing technology

constitute an ongoing process rather than an event with an end point, after which the organization can expect to return to a reasonably steady state. Therefore, organizational process change management as a strategy-driven initiative improves and (re)designs business processes to achieve competitive advantage in performance through changes in the relationships among information, technology, people, management, and organizational structure (Kettinger and Grover 1995).

Successful organizational change offers a powerful approach that will equip businesses to pursue improved performance and successfully navigate the current change challenges they face while building long-term change capabilities. Due to its focus on the improvement capability of processes and its usefulness in examining process resources, we chose the concept of change (Pasmore 1994) as the basis for analysis of the complicated contents of process capital. In addition, the process management capability is defined as the capabilities of current or future improvement, and thus every firm must at the least be able to translate the elements of events, plans and other inputs into outputs they expected. As a consequence, these capabilities can reflect the value of processes in responding to highly changing business environments.

H3: The better the management process capability, the better the business performance.

H3a: The capability to manage process changes is positively related to operational performance.

H3b: The capability to manage of process changes is positively related to managerial performance.

H3c: The capability to manage of the process changes is positively related to strategic performance.

Research Methodology

The objective of this study is to understand concepts of the measurement of process capital and to test the variables for measuring process capital. Organizations invest in processes in order to build unique infrastructure for achieving operational, managerial and strategic goals (Joeris, 1997). A complete view of the achievement of these goals requires taking into consideration short-term and long-term aspects. On the other hand, financial statements are the objective data which can enable firms to monitor the long-term and short-term flows between process and financial capital. Since the investment of process capital may not have a precise impact on current financial reports, it is necessary to take several years to filter through the business financial performance. The design of this study, therefore, is to longitudinally analyze the content of process capital and trace its evolution by attaching a monetary value to activities and assets. The following section describes how the above hypotheses were tested.

Design of the variables of process capital

Based on the concept of system model and by consolidating literature and empirical research (Edvinsson and Malone 1997; Weill 1990), the following variables are defined (Table 1).

Table 1. Variables and operationalization

Variable class	Variables	Operationalization	Indicators
Process measurement	Process inputs	Process investment	Administrative expenses + Investments in IT
	Process outputs	Productivity	Profits / Employee
	Process capability	Productivity improvement	Current yr's productivity – Prior yr's productivity
Organizational performance	Strategic	Sales growth	(Current yr's sales – Prior yr's sales) / Prior yr's sales
	Managerial	ROA	Earnings before interest, taxes and depreciation / Average total assets
	Operational	Productivity	Profits / Employee

(1) Investment in process capital

Edvinsson and Malone (1997) proposed measurement indicators of the process focus that deal with the role of technology as a tool for supporting overall enterprise value creation, including items such as administrative expenses and investment in IT. Accordingly, variables of the process input used in this study included the percentage change in operations, customers, R & D, and IT from 2002 to 2004.

(2) Output of process capital

Edvinsson and Malone (1997) proposed that process indicators should measure the actual value contribution to firm productivity. Hence, variable of the process output as defined in our study adopts measures of labor productivity from 2002 to 2005, such as profit/employee.

(3) Management capability of process capital

This study uses the percentage change of productivity as the measurement of process change management capability. Hence, data on management capabilities were generating using the difference between current year productivity and prior year productivity from 2002 to 2005.

(4) Organizational performance

This study uses performance measurement indicators proposed by Weill (1990). Since processes may require years to implement and generate returns, process capital should focus on long-term earning capability. Therefore, variables of organizational performance in this study were traced over the four years from 2002 to 2005. The measurement method used for each variable of organizational performance is described below:

- Strategic performance is generally measured against long-term goals relating to competitive advantage. The sales growth of the firm is used as one of the performance indicators in our study.
- Managerial performance is generally assessed against the medium-term goal of improving management decision making. In this study managerial performance was assessed using the financial measure ROA.
- Operational performance is evaluated using reductions in the cost of doing business by substituting capital for labor. The change in the number of people employed as production labor was used as the measure of operational performance.

Data Collection

This study selected the top 522 firm in Taiwan as the sample. Since variables of the process input cannot be collect from financial statements, we divided the measurement variables into two parts, with the financial data collected differently for each. Data for one portion, which is variables of the process input, was collected using telephone interviews, for the other, from the financial database of the Taiwan Economic Journal (TEJ). For telephone interviews, a total of 522 managers, one per firm, were contacted, all within one month. After elimination of missing data from telephone interviews, 167 valid samples remained, yielding an effective response rate of 31.99%, and we further collected data of other variables from the TEJ according to these samples. This study analyzed financial data from 167 of the 522 most important companies in Taiwan (Table 2): (1) data of process investments from 2002 to 2004 were collected by telephone interview; (2) data of process results from 2002 to 2005 were collected from the TEJ; (3) data of management capabilities from 2002 to 2005 were collected from the TEJ; (4) data on the three kinds of performance from 2002 to 2005 were also collected from the TEJ.

Table 2. Timing of the measures

	2002	2003	2004	2005
Process Input	∨	∨	∨	
Process Output	∨	∨	∨	∨
Process Capability	∨	∨	∨	∨
Business Performance - Strategic	∨	∨	∨	∨
Business Performance - Managerial	∨	∨	∨	∨
Business Performance - Operational	∨	∨	∨	∨

Research Results

The nature of the study is causal in that it attempts to estimate the relationship between variables. However, it is not possible to observe all the processes that may affect the relationships between the variables. In general, correlation analysis reveals the magnitude and direction of relationships (Cooper and Schindler 2001), so it is commonly applied to the system model. Consequently, this study uses Pearson's correlations to analyze the quantitative measures in the sample.

Measuring the input of process capital

According to Table 3, there are significant positive correlations between the input of process capital in 2002 and managerial performance from 2004 ($r=0.159$, $p<0.05$) to 2005 ($r=0.175$, $p<0.05$). The input in 2003 is also significantly positively correlated with managerial performance in 2005 ($r=0.199$, $p<0.05$). Generally speaking, prediction of performance from input is very low. Weill (1990, 1992) also found no overall relationship between process investment and performance. This result is also evidence that the rational behavior assumption is wrong. Therefore, these results support the conclusion that input variables of intellect capital may impact indirectly on output variables through the conversion effectiveness of the change process (Ackoff 1981; Maturana and Varela 1980).

Table 3. Correlations of process input and performance

Input	2002	2003	2004
'02 Strategic	-0.038		
'02 Managerial	0.035		
'02 Operational	-0.033		
'03 Strategic	-0.033	-0.049	
'03 Managerial	0.046	0.071	
'03 Operational	0.021	0.029	
'04 Strategic	0.017	0.009	0.028
'04 Managerial	0.159*	0.104	0.131
'04 Operational	0.025	-0.014	-0.009
'05 Strategic	0.022	-0.030	0.115
'05 Managerial	0.175*	0.199*	-0.024
'05 Operational	0.031	0.032	0.027

Note: * Correlation is significant at the 0.05 level (2-tailed).

Measuring the output of process capital

The correlations between the outputs of process capital and performance measures from 2002 to 2005 are shown in Table 4. All outputs are significantly ($p<0.05$) and positively correlated with managerial and operational performance from 2002 to 2005, but there is only one association between the inputs and strategic performance in 2004 ($r=0.316$, $p<0.01$). This result is

evidence that path dependency the output of process capital is useful in predicting the future value of process capital. However, path dependency is a staple of narrative methodology and a basic temporal characteristic of social and historical processes (Aminzade 1992; Pierson 2000). Håkansson and Waluszewski (2002) observed that this theory is often described in terms of restrictions or obstructions to the development of new innovations, products and technology. Since strategic performance is as long-term goals, it may be influenced by environmental or other indirect social, political, or cultural factors. Hence, this measure is only stable in association with operational (short-term) and managerial (medium-term) performances, but not strategic performance.

Table 4. Correlations of process output and performance

Output	2002	2003	2004	2005
'02 Strategic	-0.021			
'02 Managerial	0.410**			
'02 Operational	1			
'03 Strategic	-0.074	-0.032		
'03 Managerial	0.317**	0.433**		
'03 Operational	0.843**	1		
'04 Strategic	-0.048	0.097	0.316**	
'04 Managerial	0.258**	0.333**	0.227**	
'04 Operational	0.345**	0.665**	1	
'05 Strategic	-0.017	-0.077	-0.101	0.078
'05 Managerial	0.170*	0.222**	0.158*	0.396**
'05 Operational	0.181*	0.469**	0.766**	1

Note: ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

Measuring the process capital management capability

The correlations between process improvement capabilities and performance measures from 2002 to 2005 are shown in Table 5. Process improvement capabilities are all significantly ($p<0.05$) and positively correlated with operational performance from 2002 to 2005. There are also significant positive correlations between management capability in 2002 and managerial performance from 2003 ($r=0.177$, $p<0.05$) to 2004 ($r=0.174$, $p<0.05$), management capability in 2003 and managerial performance in 2005 ($r=0.153$, $p<0.05$), as well as management capability in 2005 and managerial performance in 2005 ($r=0.371$, $p<0.01$). Finally, there are significant positive correlations between management capability in 2003 and strategic performance in 2004 ($r=0.248$, $p<0.01$), management capability in 2004 and strategic performance in 2004 ($r=0.365$, $p<0.01$), as well as management capability in 2005 and strategic performance in 2005 ($r=0.260$, $p<0.01$). Barua and Mukhopadhyay (2000) noted that the organizational value of IT is the abstraction of complementarity between IT and other elements, such as business strategies, processes, and incentives, and is a critical determinant of organizational performance. Process support is

needed in both low-level technical operation and high-level management (Joeris 1997). Our results are also evidence that the dynamic execution behavior of process capital has partial and significant positive association with strategic performance. Hence, the process improvement capability is a good measure for predicting the future value of process capital.

Table 5. Correlations of management capability and performance

Management capability	2002	2003	2004	2005
'02 Strategic	0.065			
'02 Managerial	0.149			
'02 Operational	0.739**			
'03 Strategic	-0.014	0.084		
'03 Managerial	0.177*	0.129		
'03 Operational	0.675**	0.193*		
'04 Strategic	0.008	0.248**	0.365**	
'04 Managerial	0.174*	0.072	0.105	
'04 Operational	0.334**	0.463**	0.858**	
'05 Strategic	0.025	-0.098	-0.080	0.260**
'05 Managerial	0.094	0.153*	0. 055	0.371**
'05 Operational	0.172*	0.440**	0.686**	0.451**

Note: ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

Discussion

Using a system model, this study identified three kinds of measurements of process capital: the input of process capital, the output of process capital, and process capital management capability. Predictions of the variables of process measurement are subjectively judged against actual performance based on a five-point scales where "1" denotes "positively correlated weakly" and "5" denotes "positively correlated strongly." A summary of results is provided in Table 6.

Table 6. Correlations of measuring methods and performance

	Resources invested in process changes	The results of the changed processes	Capability of managing the process changes
Operational performance	H1a (0)	H2a (5)	H3a (5)
Managerial performance	H1b (2)	H2b (5)	H2b (4)
Strategic performance	H1c (0)	H3c (1)	H3c (3)

Note: this table includes hypotheses (support degree); 0= no support; 1= low support; 3=medium support; 5=high support.

Since Hypothesis 1 isn't supported, few concrete conclusions can be drawn from this study. Given that the performance of process capital is represented by firm investment in process changes (Edvinsson and Malone, 1997; Van Buren, 1999), rational behavior theory implies that the greater the amount of investment of resources is, the more obtained profit there will

be. For example, employee training is one of the indices of the knowledge management process. Firms realize that the frequency of training is able to predict the capability of current and future knowledge circulation. However, previous studies (Lee and Kim, 2006; Weill, 1990 & 1992) have indicated a positive lag effect of IT investment on business performance, and there does not appear to be a clear relationship between process investment and performance. Findings also showed that the question of the time lag between process investment and managerial performance effects is both intriguing and knotty. Pearson's correlations provide further insight into the complexity of the problem, as they fluctuate in sign and significance. In 2002, the Pearson's r's between process investment and managerial performance from 2002 to 2005 were 0.035, 0.046, 0.159*, and 0.175*, respectively. In 2003, the Pearson's r's between process investment and managerial performance from 2003 to 2005 were 0.071, 0.104, and 0.199*, respectively. In addition, the Pearson's r's between process investment in 2004 and managerial performance from 2004 to 2005 separately were 0.131 and -0.024. It is tempting to announce that the correlations have a time lag of two years. However, the relationship between process input and performance is so murky that it is not possible to identify the unique contribution of any particular year of investment. In fact, it is not clear that this can ever be achieved statistically. Future studies should consider an extremely detailed and rigorous case study to explore the time lag issue.

H2a and H2b are significantly supported. The measure of process output appears to significantly predict managerial and operational performance and may lead to stable effects every year. However, this analysis emphasizes final process results, not potential, and usually uncovers the real value of process capital. Sambamurthy *et al.* (2003) indicated strategic execution requires dependence on many factors, such as organizational capabilities (agility, digital options, and entrepreneurial alertness) and strategic processes (capability-building, entrepreneurial action, and coevolutionary adaptation). Findings show that even if current execution is good, it is unlikely to affect strategic performance. For instance, the market share of a software corporation may be taken as its benefit in measurements of its system development process. Unfortunately, market share may be affected by other factors, such as product design and marketing strategy. In addition, findings appear to show that the conversion effectiveness of IT is a key factor in creating a more valuable output (Weill and Olson 1989; Weill 1990). Past and current information may facilitate the resource management and decision making processes. Basically, process results have only a limited effectiveness in predicting future operational and managerial success, but are affected by numerous contingencies that make reliable long-term prediction impossible. Hence, measurements of efficiency should consider many indirect factors.

Finally, with Hypothesis 3 significantly supported, this study provides evidence that management capabilities are dynamic, a recursive flow of processes that continuously learn and change for better adaptation to the environment. Unfortunately, environmental factors, such as the Iraq War or SARS in 2003 and 2004, impacted strategic performance, reducing the impact

of these capabilities in 2003 and 2004. Given the continuously changing environment, organizations have to dynamically manage the flow of change to fit long-term and strategic goals. However, Joeris (1997) indicated changes may lead to on-the-fly modifications of the planned activities. Firms have to decide when these changes should be bred into the affected process steps, meaning that these processes may be as complex as the overall development process. Therefore, our results show that process improvement capability sometimes impacts strategic performance rather than managerial performance. In other words, the sustainable business value of IT emerges especially through its integration and configuration with business strategies, organizational structures, and capabilities (Barua and Mukhopadhyay 2000). Sambamurthy *et al.* (2003) also found these dynamic capabilities and strategic processes impact firm performance. As a consequence, the ability to manage process changes seems to have a greater impact on sustainable strategic competitiveness, implying that firms should reframe the strategic role of IT as a digital options generator.

Conclusion

Based on the IOP elements of process capital, the analysis used in this study can predict the value of process capital by analyzing the past, current and future potential capabilities from the IOP perspectives. We refined the existing knowledge of intellectual capital by distinguishing three kinds of organizational capabilities. First, investment in process capital requires that firms need to manage investment with technology and business resources. Second, the output view of process capital focuses on their ability to predict the future value of process capital. Third, management capability provides process adaptability, including planning, designing, managing, and improving business processes, in a constantly changing environment, and this analysis seems most effective in predicting strategic performance in the long-term.

Organizational performance is mainly operationalized using financial measures or measures of volume: for instance, pre-tax return on assets (ROA), productivity, and contributions to profits. Measures of volume include sales and sales growth. Organizational performance has rarely been used in IT research models. In this study, a broad set of measures is used to operationalize organizational performance, including productivity (operational), ROA (managerial), and sales growth (strategic).

Operational data were analyzed using 3 to 4 years of financial information. This study compared Pearson correlation coefficients between the IOP variables of process capital in any one particular year and the three kinds of performances. Our findings include: (1) although even a limited process improvement significantly and positively impacts managerial performance, these relationships are too weak to predict future performance; (2) the output of process improvement

significantly and positively impacts operational and managerial performance. These relationships are very stable, so this method is effective. However, our method is affected by numerous contingencies and is of only limited effectiveness in predicting strategic performance; (3) this study found that the process management capability can significantly impact not only operational and managerial performance, but also strategic performance. Furthermore, both the output and the process measures can effectively predict the short and long term value of process capital, and the latter appears to have the strongest impact on strategic performance.

In conclusion, the contributions of this study are twofold. First, the IPO elements of the system model can be applied not only to process capital but also to other kinds of intellectual capital, such as human capital, relational capital, innovation capital, and customer capital. Second, management capability has the predicted effect on the short-term, medium-term, and long-term performances, so we highlighted process change management capabilities, providing insights for managers and academics. Future research should use a cross-case study and a multi-dimensional analysis to explore the dynamic nature of process capital and to further validate and measure these dimensions.

References

Ackoff, R. L. Creating the Corporate Future, New York: John Wiley, 1981.

Aminzade, R. "Historical Sociology and Time," Sociological Methods and Research (20), 1992, pp. 459-80.

Bontis, N. World Congress on Intellectual Capital Readings, Boston: Butterworth-Heinemann/KMCI Press, 2002.

Bontis, N., Keow, W. C. C., and Richardson, S. "Intellectual Capital and Business Performance in Malaysian Industries," Journal of Intellectual Capital (1:1), 2000, pp. 85-100.

Carr, N. G. Does IT Matter?: Information Technology and the Corrosion of Competitive Advantage, Boston, Massachusetts: Harvard Business School Press, 2004.

Chan, J. "Toward a Unified View of Customer Relationship Management," Journal of American Academy of Business (6:1), 2005, pp. 32-38.

Cohen, W. M., and Levinthal, D. A. "Absoptive Capacity: A New Perspective on Learning and Innovation," Administrative Science Quarterly (35:1), 1990, pp. 128-152.

Cooper, D. R., and Schindler, P. S. Business Research Methods, Seventh Edition, New York: McGraw-Hill International Edition, 2001.

Edvinsson, L., and Malone, M. S. Intellectual Capital: Realizing Your Company's True Value by Finding its Hidden Brainpower, New York: HarperCollins Publishers, 1997.

Fitzgerald, B. AMR Research Report Says the Supply Chain Management Market Remains Steady, Grew 3% to $5.6B in 2005, AMR Research, 2006, http://www.amrresearch.com/Content/View.asp?pmillid=19728, as of 05/09/2006.

Foss, B., Devonport, C. P., and McDaid, P. "Achieving ROI from E-business Systems in Financial Services," in B. Foss, and M. Stone (Ed), CRM in Financial Services: A Practical Guide to Making Customer Relationship Management Work (pp. 280-301), London: Kogan Page, 2002.

Håkansson, H., and Waluszewski, A. "Path Dependence: Restricting or Facilitating Technical Development," Journal of Business Research (55:7), 2002, pp. 561-570.

Joeris, G. Change Management Needs Integrated Process and Configuration Management, In: Software Engineering Notes, Proceedings of 6th European Software Engineering Conference, Zurich, Switzerland, 1997, pp. 125-141.

Johnson, W. H. A. "An Integrative Taxonomy of Intellectual Capital: Measuring the Stock and Flow of Intellectual Capital Components in the Firm," International Journal of Technology Management (18: 5/6/7/8), 1999, pp. 562-575.

Kannan, G., and Aulbur, W. G. "Intellectual Capital Measurement Effectiveness," Journal of Intellectual Capital (5:3), 2004, pp. 389-413.

Kautz, K., and Thaysen, K. "Knowledge, Learning and IT Support in a Small Software Company," Journal of Knowledge Management (5:4), 2001, pp. 349-357.

Kettinger, W. J., and Grover, V. "Special Section: Toward a Theory of Business Process Change Management," Journal of Management Information System (12:1), 1995, pp. 9-30.

Lee, S., and Kim, S. H. "A Lag Effect of IT Investment on firm Performance," Information Resources Management Journal (19:1), 2006, pp. 43-69.

Malhotra, Y. "Knowledge Assets in the Global Economy: Assessment of National Intellectual Capital," Journal of Global Information Management (8:3), 2000, pp. 5-15.

Morphy, E. Global CRM Market to Surpass $11 Billion by 2008, CRM Daily, 2004, http://www.crm-daily.com/story.xhtml?story_id=26128, as of 02/08/2004.

Pasmore, W. A. Creating Strategic Change: Designing the Flexible, High-Performing Organization, New York: John Wiley & Sons, 1994.

Pierson, P. "Increasing Returns, Path Dependence, and the Study of Politics," American Political Science Review (94), 2000, pp. 251-67.

Roos, G., and Roos, J. "Measuring Your Company's Intellectual Performance," Long Range Planning (30:3), 1997, pp. 413-426.

Sambamurthy, V., Bharadwaj, A., and Grover, V. "Shaping Agility through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms," MIS Quarterly (27:2), 2003, pp. 237-263.

Shepherd, J., Locke, B., D'Aquila, M., and Carter, K. The Enterprise Resource Planning Report, 2004-2009, AMR Research, 2005, http://www.amrresearch.com/Content/View.asp?pmillid=18312, as of 15/06/2005.

Teece D. J. Managing Intellectual Capital, UK: Oxford University Press, 2000.

Teece, D. J., Pisano, G., and Shuen, A. "Dynamic Capabilities and Strategic Management," Strategic Management Journal (18:7), 1997, pp. 509-533.

Van Buren, M. E. "A Yardstick for Knowledge Management," Training & Development (53:5), 1999, pp. 71-77.

Von Bertalanffy, L. General System Theory: Foundation, Development, and Applications, New York: George Braziller, 1968.

Weill, P. and Olson, M. H. "Managing Investment in Information Technology: Mini Case Examples and Implications," Management Information Systems Quarterly (13:1), March 1989, pp. 3-17.

Weill, P. Do Computers Pay Off, Washington, D.C.: International Center for Information Technologies, 1990.

Weill, P. "The Relationship between Investment in Information Technology and Firm Performance: A Study of the Valve Manufacturing Sector," Information Systems Research (3:4), 1992, pp. 307-333.